Marine Physical Laboratory

ULF/VLF Noise on Basalt and Sediment (NOBS)

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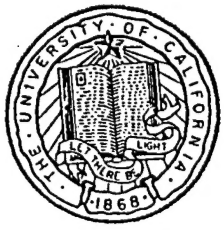

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Abstract

This experiment undertook a comparison between noise and seismic signal fields on seafloor of two different structural types. Arrays of newly-constructed ONR OBSs were deployed on the flanks of the Gorda Ridge, Juan De Fuca Ridge, and in the Cascadia Basin. These instruments made simultaneous observations of seafloor noise, in addition to some earthquakes. The primary question addressed was "Is seafloor noise smaller at hard-bottom (basalt) seafloor sites than it is at thickly-sedimented sites?". The answer depends on the frequency.

SUMMARY

This report covers the deployment of 14 OBSs as part of the NOBS experiment. These instruments were deployed near the north end of the Gorda Ridge and in the Cascadia Basin. Several short airgun lines and a series of bottom shots were fired to the several arrays. Prior to the main deployment a set of three short test deployments was made with the instruments set at 128 Hz sampling rate. For the main deployment, a sample rate of 32 Hz was used to conserve storage space.

INTRODUCTION

The goal of the NOBS experiment is increased understanding of the interaction of seafloor noise with the geological-geophysical structure of the seafloor. More simply stated, does the high compliance of the seafloor at sediment-covered sites increase the amplitude of the noise there and if it does, how does this affect the signal-to-noise ratio of seafloor-mounted sensors.

Answering these questions requires observation of seafloor noise and signals at sedimented and sediment-free sites under the same oceanographic conditions. The type of propagation of the noise is also of interest. Determination of th propagation velocity is the simplest way to accomplish this so the experiment entails installation of arrays of seafloor sensors at the several locations. Choice of an experiment site was based on the need for fairly thick (>50 m) sediment cover near unsedimented seafloor. The plate tectonic environment which provides this is a ridge-transform fault intersection. The closest such environment which has both windy and calm weather is at the Blanco Fracture Zone and its intersection with the Gorda and Juan de Fuca Ridges. The intersection with the Gorda Ridge abuts the generously-sedimented Cascadia Basin so it was chosen.

R/P FLIP was equipped with multichannel Doppler Sonar and a wave wire array to provide measurements of the ocean wave field.

Previous experiments with seafloor arrays has shown us that much of the noise in the 0.05-10 Hz frequency range travels as surface/interface waves. The propagation velocity of these waves (the dispersion curves) is determined by the shear velocity structure of the seafloor. The most direct way to measure this dispersion is by firing explosions on the seafloor. This provides data in the 1-5 Hz frequency range at sedimented sites.

NARRATIVE

The R/V NEW HORIZON was staged out of San Diego during the week prior to departure. Staging included the installation of a "portable" Diesel-driven air compressor on the main deck. Construction of the mounting hardware and installation of cooling water supply for the air compressor was supported by the University of California. The 8.25 ton weight of the air compressor and the 9 ton weight of the OBSs required removal of the drum from the trawl winch on the boat deck and special attention to liquid free surface management to maintain adequate ship stability.

The 15 OBS frames were stowed on the main deck within reach of the Nautilus crane. Some of the pressure cases were stowed on the OBS frames and others were stored in specially constructed carts and storage frames. The deck space occupied by the OBSs, air compressor and air guns precluded use of a portable lab (van) on deck so the ships lab was set up with 2 OBS checkout stations.

NEW HORIZON was underway at about 12:30 local time on 26 August for pier BRAVO at the Naval Air Station, North Island, to load explosives for the bottom shots. Immediately following explosives loading, the ship departed for the experiment site. Transit to the tip of the Gorda Ridge took just over 3 days.

Previous experience with the external sensor package deployment system indicated difficulty in obtaining reliable deployment because of susceptibility of the release foot to physical damage, either on instrument launch or upon contact with the seafloor. Additionally, the external package would sometimes be released by dynamic water forces on the release foot. Much of the seafloor in the experimental area is rough so half of the instruments were modified so that the sensor packages were mounted rigidly to the fiberglass instrument frame. The instruments so modified are identified by an "H" (for hardmount) in the drop summary table. Unmodified instruments are identified by an "S". The hardmount configuration was new so a test deployment was deemed prudent.

On 29 August, three OBSs were deployed on a shelf in the median valley of the Gorda Ridge as a test of the new sensor configuration and also to gather information on the P-wave structure. These instruments were programmed with the same recording schedule used in the main deployment. These instruments were set to 128 Hz sample rate and, on 31 August, an airgun profile was shot to these instruments. These three instruments were recovered on 1 and 2 September. Two instruments performed well, recording data as programmed. One instrument failed to write data reliably, alternating written and empty blocks on the optical disk.

On 30 August the Cox/Jacobs Cartesian Diver was dropped to measure vertical water motions in the upper ocean. It was recovered on 4 September. Upon recovery, the instrument, which is somewhat delicate, suffered damage which was unrepairable at sea and was not used further.

On August 31, an airgun line was shot to the 3 deployed instruments using 2 guns of 550 cubic inches, one of 300 and one of 200 cubic inch chambers. A midwater test of a shot timer

(firing a blasting cap) was made.

On 1 September, deployment of OBSs for the long deployment began, interleaved with recovery of the instruments from the first 3 deployments.

Examination of the data from the test deployments showed that the attachment of the sensor package to the frame produced no apparent ill effects. The waveforms and frequency content of the horizontal components were not sensibly different from those of the vertical components.

In view of the recording problem with one of the OBSs during the test deployment and after consultation with John Hallinan, the decision was taken to install a π-section LC lowpass filter in the power supplies to the Maxtor disk recorder. This had been installed in the units at WHOI but the recording packages shipped to SIO were the ones which had seemed less susceptible to drive shutdown because of excess power supply ripple. Ken Peal kindly airshipped the necessary components to us and NEW HORIZON returned to Newport, OR to pick them up. These filters were installed in the 9 units deployed after the trip into Newport.

At the Newport stop David Jacobs and Marty Dougherty left the ship.

The instruments were deployed in three arrays;

Array A was at a depth of 2700 meters on the east flank of the Gorda Ridge. This site is at a relatively smooth spot on fairly normal-looking abyssal hill topography. It is the "typical" thinly sedimented site. The array center is about 42° 50.4' N, 126° 22.7'W and contains 9 OBSs.

Array C is on a very flat seafloor at the tip of the Gorda Ridge at a depth of 3125 meters. There is little or no sediment. This site was chosen to provide a very "hardrock" environment but is in the median valley and is shielded from distant noise sources so it is atypical seafloor in that sense. The site of this array, at the junction of rise axis and fracture zone, should provide data for several natural-source experiments. The array center is about 43° 01.5'N, 126° 35.75'N and contains 10 OBSs.

Array D surrounds FLIP and is located on very flat sediments in the Cascadia Basin, nominally on the extension of the Gorda Ridge spreading axis. The water depth is 3055 meters. 7 OBSs are located here.

Array J is on the Juan de Fuca Ridge just east of the spreading axis. It provides a comparison between different ridge sites and consists of 3 OBSs.

The larger three arrys were designed to provide a large number of interelement offsets using few elements. The array surrounding FLIP was based on the use of FLIP's telemetered array as a 300m-diameter center element.

After the first three drops, the instruments were configured to 32 Hz samples per second, with the anti-aliasing filters set to 8 Hz. This sample rate permits recording of about 17 days of data. Our goal is to monitor the meteorology for about a month so some compromise was in order. Simply dividing the instruments into two groups with a 50% duty cycle would provide adequate time coverage but not allow effective array utilization in terms of inter-instrument coherences, since all the instruments would never be recording at the same time. Dividing the instruments into three groups, however, allowed continuous coverage by at least one group and provide some time periods during which all the instruments were recording.

Instrument Status

Intensive efforts by the engineering staff of both the East and West Coast facilities resulted in the alleviation of many of the problems and reduction or elimination of most of the noise sources which have been seen on earlier deployments of the instruments. Some problems, however, remain. Manpower and time limitations have not allowed implementation of all of the improvements on all of the instruments. Curiously, all instruments do not derive the same benefit (in noise improvement) from some of the changes.

Data Recovery

The first 3 deployments deployments were short test drops of four-day duration. Two of these instruments performed well, recording as programmed. Instrument 5 seems to have recorded into alternate blocks on the optical disk, for no reason that we have been able to discover.

Airgun Shooting Program

Airgun lines were shot over the test deployment sites and over the arrays, after they were completely deployed. The nominal ship speed was two knots and the shot interval was 70 seconds. The airgun array consisted of 1-200 in^3, 1-300 in^3, and 2-550 in^3 guns.

DEPLOYMENT TIMES, LOCATIONS AND DEPTHS

Frame	Sched	Launch Time	Recovery Time	Location	Depth (m)	Duration
#9H	C	242 02:13:30	245 00:20	42° 57.373N 126° 32.2W	3070	2.92 days
#10H	B	242 03:19:00	246 04:28	42° 58.002N 126° 31.575W	~3070	4.05 days
#5H	A	242 03:34:00	246 18:18	42° 57.583N 126° 31.778W	~3070	4.61 days
#4H	A	244 21:15:00	286 07:00	43° 01.302N 126° 35.603	~3125	41.41 days
#1H	B	244 21:36:00	286 08:40	43° 01.443N 126° 36.191	3125	41.46 days
#6H	C	245 21:36:00	285 20:10	42° 50.210N 126° 22.593	2655	39.95 days
#2H	A	245 22:31:40	285 16:45	42° 50.337N 126° 23.117	2700	39.76 days
#9H	B	245 22:58:15	285 08:51	42° 50.677N 126° 22.857	2684	39.41 days
#5H	C	245 23:23:25	285 15:00	42° 50.455N 126° 22.503	2690	39.65 days
#13H	B	247 23:54:20	285 10:30	42° 50.571N 126° 13.000	~2700	37.44 days
#12S	A	250 22:21:45	287 10:30	42° 42.348N 125° 59.057	3055	39.49 days
#15S	B	250 22:42:45	287 11:00	43° 42.617N 125° 59.273	3055	36.51 days
#8S	A	252 22:07:10	287 13:35	43° 41.806N 125° 58.376	3055	34.64 days
#7S	C	255 19:52:10	287 12:15	43° 41.785N 125° 59.855	3055	31.68 days
#14S	C	255 22:05:00	287 13:10	43° 41.760N 125° 59.005	3055	31.62 days
#11S	B	255 20:16:00	287 11:50	43° 42.045N 125° 59.680	3055	31.64 days
#10S	C	255 20:42:30		43° 42.603N 125° 58.808	3055	
#65H	A	248 00:00:00		44° 56.97N 130° 12.99		
#57H	B	248 00:00:00	288 09:10	44° 57.11N 130° 13.36		40.00 days
#54H	C	248 00:00:00	288 10:20	44° 56.81N 130° 13.31		40.00 days
#51S	A	248 00:00:00	286 11:50	43° 01.52N 126° 35.49		38.00 days
#59S	C	248 00:00:00	286 15:20	43° 01.75N 126° 35.62		38.00 days
#64S	A	248 00:00:00	286 11:10	43° 01.51N 126° 35.68		38.00 days
#62S	B	248 00:00:00	286 07:50	43° 01.32N 126° 35.83		38.00 days
#63S	C	248 00:00:00	286 10:20	43° 01.53N 126° 35.86		38.00 days
#56S	B	248 00:00:00	286 09:00	43° 01.47N 126° 35.75		38.00 days
#60H	C	248 00:00:00	286 14:00	43° 01.69N 126° 35.98		38.00 days
#52H	A	248 00:00:00	286 12:30	43° 01.63N 126° 35.76		38.00 days
#61S	A	248 00:00:00	285 18:40	42° 50.26N 126° 22.88		37.00 days
#55H	A	248 00:00:00	285 11:55	42° 50.57N 126° 22.86		37.00 days
#58H	B	248 00:00:00	285 19:00	42° 50.43N 126° 22.80		37.00 days
#53H	B	248 00:00:00	285 13:30	42° 50.50N 126° 22.89		37.00 days

BOTTOM SHOT INFORMATION

Shot	Drop Time	Shot Time	Location	Size(kg)	Size(kg)	Comments
1	251 18:11:00	252 00:05	42° 50.568'N 126° 22.670'W	15.5		
2	251 20:05:00	252 04:05	42° 50.123'N 126° 23.014'W	15.5		
3	251 22:37:10	252 04:15	43° 01.566'N 126° 35.747'W	15.9		
4	251 23:25:00	252 04:25	43° 01.169'N 126° 36.112'W	15.9		
5	254 17:29:00	254 20:40	42° 50.229'N 126° 23.066'W	11.4	+	
6	254 20:36:00	254 21:15	42° 50.921'N 126° 23.530'W	11.4	*+ Wireline shot	
7	255 07:07:07	255 12:10	43° 01.273'N 126° 36.011'W	11.4		
8	255 17:51:15	255 12:30	43° 01.452'N 126° 35.593'W	11.4		
9	257 03:53:35	257 05:35	42° 50.376'N 126° 23.130'W	11.4	+	
10	257 06:11:20	257 12:05	42° 50.417'N 126° 22.456'W	11.4	+	
11	257 XX:05:00	257 20:05	43° 01.354'N 126° 35.033'W	11.4	*+	
12	257 18:16:20	257 20:45	43° 01.572'N 126° 35.632'W	11.4	*+	
13	258 07:33:30	258 13:30	43° 41.473'N 126° 00.100'W	11.4	*	
14	258 08:15:30	258 13:45	43° 42.870'N 126° 59.135'W	11.4	*	
15	259 01:29:10	259 12:05	43° 41.774'N 125° 58.242'W	12.7	dud	
16	259 02:17:20	259 12:15	43° 42.061'N 125° 58.431'W	12.3	*,recorded	
17	259 07:39:50	259~12:22	43° 42.269'N 125° 59.653'W	20.4	*,recorded	
18	259 08:14:40	259 12:35	43° 43.192'N 125° 59.608'W	22.7	*,recorded	

A * indicates that the shot was heard aboard ship. A + indicates that the shot was detected by the SOSUS system. "Recorded" means that the shot pressure wave was digitized using a hydrophone suspended beneath the ship.

Scientists and Crew of the New Horizon - August 26 - Sept 19, 1991			
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Paul Porcioncula	Ed Lograsso		Cooks

This grant has produced one manuscript which has been accepted by the Bulletin of the Seismological Society of America (subject to revisions) and a number of abstracts. Analysis of the noise data is continuing under other funding.

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